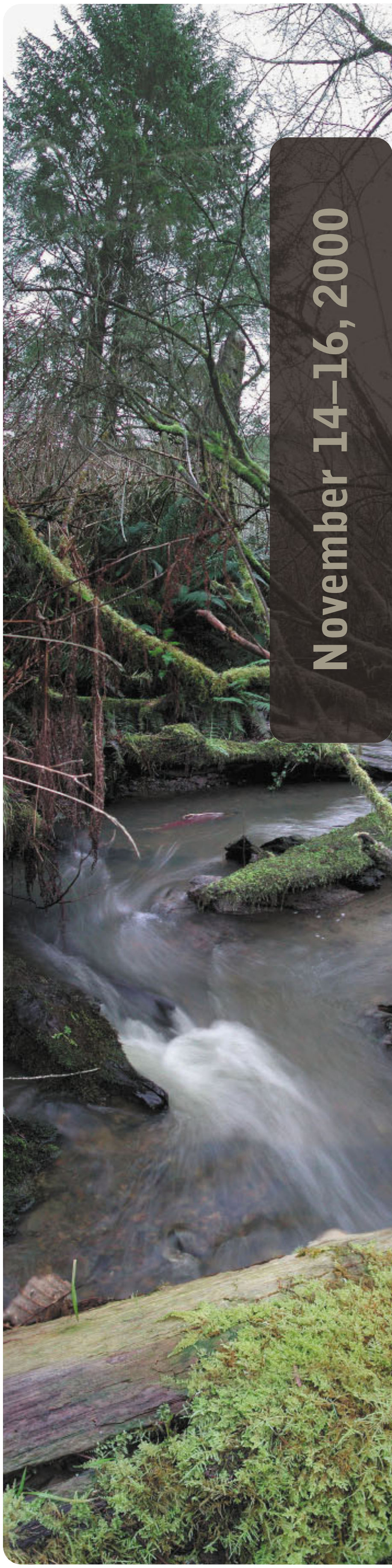

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Proceedings of the Salmon Habitat Restoration Cost Workshop

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Workshop Conclusions and Recommendations

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INTRODUCTION

Participants at the Salmon Habitat Restoration Cost Workshop provided thoughtful insights into many aspects of habitat restoration. This paper is an attempt to synthesize some common themes from the presentations as they relate to the three overall topics of the workshop: estimating restoration costs at the individual project level, feasibility of extrapolating project-level costs to larger geographic scales, and types of data needed to do such extrapolation. The paper concludes with a summary of workshop recommendations.

RESTORATION COSTS IN THE LARGER CONTEXT OF HABITAT RESTORATION ECONOMICS

Huppert describes various types of economic analyses that can be used to evaluate trade-offs associated with habitat restoration. *Cost analysis* is used to estimate the value of resources foregone to accomplish a particular activity (e.g., a restoration project or program). *Cost-effectiveness analysis* is used to evaluate restoration activities in terms of cost per unit of effectiveness, that is, to determine which activities provide the "biggest bang for the buck"; this type of analysis requires that all projects be characterized according to a common unit of effectiveness. *Benefit-cost analysis* is used to evaluate activities in terms of the relative size of benefits and costs; benefits and costs must be expressed in common units (i.e., dollars) in order to conduct this type of analysis. *Economic impact analysis* is used to estimate effects of restoration activities on income and employment in local economies. Huppert also clarifies the concept of "opportunity cost" as used in economic analysis to include the value of goods and services foregone in order to achieve restoration.[1] Based on this concept, restoration costs include not only direct expenditures but also (for instance) the value of crops foregone to increase instream flow. Huppert's paper thus provides a larger economic context for the workshop, which focused on the complexities associated with one component of economic costs, namely, direct restoration expenditures.[2]

1- Opportunity costs are similarly incurred if restoration is foregone. As noted by Rectenwald, "...hidden costs that can be substantial from a biological perspective are delayed restoration actions due to lack of decision making ability, controversy and/or litigation. Some of the species in the watersheds have such low population levels that they do not have much time to begin recovery so they can exist in the future" (p. 205).

PROVIDING A COMPARABLE COST BASIS FOR EVALUATING RESTORATION PROJECTS

It is important that restoration project costs be evaluated in a comprehensive and comparable manner (see Huppert, Wellman, Weaver/Hagans, Neal, Hayes, Hudson). For instance, cost analysis should ideally include all costs incurred over the life cycle of a project. Multi-year costs should be corrected for inflation to the same year and an appropriate discount rate applied to annual cost estimates. In comparing costs across projects, it is important to consider whether data on comparable cost elements are available for each project and whether the projects were designed to meet similar standards of what constitutes restoration.

Meaningful comparisons of project costs are often difficult to achieve, for a number of practical reasons.

Difficulty of obtaining data on actual costs: Wellman's systematic evaluation of 47 restoration projects (which revealed some significant differences between estimated and actual costs) suggests that cost comparisons across projects are best done on the basis of actual costs. However, as indicated by Carlson/Allen's experiences with the California Habitat Restoration Project Database, cost estimates included in project proposals are often more readily available than data on actual costs incurred. Records of actual costs (e.g., from invoices or final reports) are not always maintained in a complete or consistent manner and can be difficult to reconstruct, especially if records are kept in paper rather than electronic files.

Accounting practices: Not all costs associated with procurement of funding, planning, design, permitting, public outreach, contract administration, construction supervision, maintenance and monitoring are necessarily billed to the project. Even in cases where such services are billed to the project, applicable overhead rates and the types of costs covered by those overhead rates may vary, due to differences in financial accounting practices among administrative entities.

Spending caps: Some of the differences in project costs may be attributable to different constraints imposed by project sponsors. For instance, it is not uncommon for sponsors to cap the amount of money that can be spent on particular aspects of a project. Given the strong incentive to get projects on the ground, it is more typical for planning, design, maintenance and/or monitoring costs to be capped than construction costs.[3]

Multiple funding sources: Some projects have multiple funding sources. While individual sponsors typically monitor the costs associated with their own share of a project, they do not necessarily have information on the costs covered by other co-sponsors. In such situations, it may be difficult to determine the total cost of the project, due to the difficulty of piecing together cost information from the various co-sponsors (see Carlson/Allen).

Allocating costs among projects: Some contracts cover a mix of fairly discrete restoration activities (e.g., restoration at multiple sites). Putting diverse projects under the umbrella of a single contract is often cost-effective and administratively efficient. However, it also complicates attempts to allocate contract costs among projects, particularly if the costs reported on contract invoices are lumped in such a way as to

2- Huppert is aware of the limitations as well as strengths of economics. As he notes, "Social values, pre-existing commitments, and property rights often preclude or limit the role of economic information in decisions. There are over-arching social and ethical considerations in some cases that overshadow economic consequences and make economic information less crucial to public decisions" (p. 24).

3- For instance, the California Department of Fish and Game's Fishery Restoration Grants Program caps road inventory and assessment costs at $1,200 per mile (see Weaver/Hagans) and equipment purchase at $5,000 (see Bell). Neal notes that capital construction projects undertaken in King County are capped at $70,000. According to Obradovich, the Army Corps of Engineers caps land acquisition at 25%, monitoring at 1% and adaptive management at 3% of total project costs.

effectively preclude any practical attempt at cost allocation (see Carlson/Allen).

Treatment of in-kind contributions: Restoration projects often involve in-kind contributions by watershed councils and other groups that mobilize public participation. While it is important that such contributions be recognized as part of project costs, determining the extent of in-kind work and imputing a value to it is not always easily done.

Making within-category cost comparisons: Even in cases where projects are similar in terms of restoration requirements and total costs, differences in contract incentives or restoration strategies can affect how expenditures are distributed across cost categories. For instance, contractors who are allowed to recover some of their mobilization costs up front may bid mobilization higher and construction lower than contractors who are not given this option. Another example pertains to the division of expenditures between labor and equipment on revegetation projects, which may depend on whether the work is done mechanically or by hand crews.

FACTORS AFFECTING RESTORATION STRATEGIES AND COSTS

While disparities in accounting practices can create apparent cost differences among projects, costs are also affected in substantive ways by site-specific factors and institutional constraints. The following is a brief description of major cost factors identified by workshop participants. While the specific effects of each factor vary from project to project, all of the factors are universal in terms of their potential applicability to the various types of restoration activities discussed at the workshop.

Project Objective

Restoration strategies and associated costs vary among projects, depending on the objective. For instance, Jani identifies several potential reasons for repairing stream crossings (i.e., recover salmonids, protect other aquatic species, meet Environmental Protection Agency standards for Total Maximum Daily Loads). Weaver/Hagans note the importance of distinguishing between road restoration that facilitates salmonid recovery by reducing sediment delivery versus road improvements that enhance transportation. Coffin notes that road decommissioning can mean different things to different people (e.g., road closure, elimination of slope stability problems, complete topographic obliteration of the road).

Workshop participants emphasize the importance of diagnosing site-specific problems in the context of the watershed in which they occur. This requires careful consideration of the interconnectedness of the site with the watershed (see Weaver/Hagans, Cocke, Bell, Neal, Rectenwald). Site-specific considerations pertain not only to current conditions but also expected future conditions at the site. For instance, Weaver/Hagans point out the importance of "forward looking" sediment inventories that anticipate future road problems rather than merely document historic problems. Jani suggests rolling dips as a suitable low-cost alternative to cross drains for directing runoff from roads that are not expected to be used year-round. Cocke describes erosion control measures at a bridge implemented in anticipation of increased traffic associated with nearby subdivision development. Bell points out the limited utility of instream restoration in areas that are expected to be clear cut in the near future. Hayes notes the importance of designing Central Valley fish screens to handle significant debris loads under a wide variety of flow conditions.

Project Design Standards

In many cases, Federal and State agencies provide design standards for restoration activities that fall under their jurisdiction. Additionally, a number of government and non-government entities have produced habitat restoration manuals and cost guidelines that facilitate the work of restoration practitioners. Workshop participants provide numerous examples of design standards. For instance, Shaw notes that restoration done by conservation districts must comply with Natural Resources Conservation Service design standards. Dupont notes that stream crossings must typically be designed to withstand 50- to 100-year peak flow events. The stringency of design standards and the strictness with which they are enforced can have a significant effect on the restoration strategy chosen and associated costs. For instance, Hayes and Hudson point out that National Marine Fisheries Service design standards for fish screens have had a significant effect on the cost and feasibility of screening projects.

Project Size and Complexity

Project size can be defined in a variety of ways. For road projects, costs generally increase with the number of road miles and stream crossings treated, and also with the volume of sediment and the number and size of culverts that must be removed (see Coffin, Weaver/Hagans). Restoration costs in riparian areas increase with the number of acres requiring revegetation or number of miles requiring fencing. Channel size can affect stream restoration costs in terms of planning, design and heavy equipment requirements, and the number, size and complexity of materials (e.g., logs, boulders, bank barbs) required to do the job (see Shaw, Bair, Bell, Neal). Fish screening costs are affected by the size of the diversion being screened (see Hayes, Hudson). Wetland restoration costs increase with the size of the project (size often being related to design requirements) and the volume of soil being moved (see Bonsignore/Liske, Obradovich, Steere).

While larger restoration projects generally cost more than smaller ones, costs may increase less than proportionately with the size of the project (see Wellman, Coffin, Weaver/Hagans, Bair, Hudson, Kepshire, Steere). Materials may be discounted and contractors may be willing to work at lower rates because of the increased job security associated with larger contracts. Mobilization costs, as well as overhead and administrative costs, may also be subject to economies of scale. Large-scale projects may become more cost-effective as construction crews become more familiar and proficient with work requirements. Design requirements may not be proportional to the size of the project. For instance, Kepshire notes that, while fish screen costs tend to increase with the flow rate (measured in cubic feet per second, CFS) that the screen is intended to accommodate, the cost per CFS tends to decrease with project size. Steere points out that doubling wetland acreage does not necessarily require doubling the number of wetland structures (e.g., pumps), as such structures often provide good wetland functioning for a range of wetland sizes.

On the other hand, large or complex restoration projects also pose significant challenges (see Rectenwald, Bonsignore/Liske, Obradovich, Steere). Information, planning and consultation requirements tend to increase with size and complexity. Complex projects that extend over a prolonged period may require exceptional persistence to ensure that the project does not lose momentum or get sidetracked from its ultimate objective. Obtaining a complete cost accounting of such projects is likely to be challenging, particularly if extensive consultation among multiple parties is required in the planning phase.

Availability of Materials, Equipment and Labor

Availability of materials, equipment and labor varies with local conditions (see Shaw, Coffin, Jani, Bair, Cocke, Neal, Bonsignore/Liske, Obradovich, Steere). A requirement to revegetate riparian or wetland areas with native plant stock may be difficult to meet, depending on the availability of such materials in their natural settings and the cost of obtaining adequate stocks from nurseries. Appropriate soils to build wetland structures may need to be imported if they are unavailable at the restoration site. Heavy equipment may not be readily available in some forest areas due, for instance, to the decline of the construction infrastructure that once supported the logging industry. Changes in forest practices have reduced the amount of woody debris available for restoration, and considerable time and effort may be required to stockpile an adequate supply of wood for a project (e.g., by salvaging trees downed by storms). Restoration practitioners often seek "recycling" opportunities — e.g., salvaging culverts, soil or rock from one project for use on another project; transforming soil excavated at wetland sites into levies or bird islands — as a way to cut costs.

Availability is also a matter of timing (see Shaw, Cocke, Steere). When the local economy is strong or in the aftermath of events such as fire or flood, competition for construction contractors tends to bid up equipment rental and labor rates and result in higher bids on restoration projects. Costs may also exhibit a seasonal pattern, with restoration projects costing less at the beginning of the construction season, when contractors are more eager to obtain work, than at the end, when the availability of contractors tends to dwindle.

Skill and Experience

Skill and experience of personnel are critically important in all phases of a project (see Wellman, Shaw, Jani, Weaver/Hagans, Cocke, Bell, Neal, Obradovich). Cost-effectiveness is greatly enhanced by sound advice in the assessment and design phase, competent and attentive construction supervision, and crews who are skilled equipment operators, know the local area and have prior experience with similar projects.[4] Competent work in one phase of a project enhances performance in other phases. Thus, for instance, competent planning reduces the likelihood of problems in the construction phase; capable construction crews require less supervision than inexperienced ones. Depending on the nature of the work, Conservation Corps, Americorps, and volunteer programs (including local watershed groups) may be cost-effective sources of labor.

Site Accessibility

Legal or physical impediments may need to be addressed in order to obtain access to the restoration site.

Legal Access

The legal right to conduct restoration may need to be secured by measures such as zoning, purchase of land or easements (see Wellman, Shaw, Neal, Hudson, Rectenwald, Obradovich). The cost of land is affected not only by the initial purchase price but also by any long term commitments (e.g., property taxes) that may accompany the purchase.[5] Easement costs are affected by the duration of the easement and by whether the intent is merely to secure access or to impose additional restrictions (e.g., preclude future development in the easement). Access in developed areas may require consultation with multiple parties. Neal, for example, notes that, in King County, permission must be obtained from the majority of homeowners in a subdivision in order to construct a riparian corridor set aside as part of the subdivision. Access can pertain to water as well as terrestrial rights. For instance, Rectenwald describes a dam removal project

4- Jani provides a particularly vivid picture of the role of skill and ingenuity in developing cost-effective solutions to difficult restoration problems. See, for instance, his description of how to install a bridge when equipment can be positioned on only one side of the stream and the area is inaccessible to a crane.

5- According to Shaw, this is not an issue for Federal entities, which are exempt from State and local property taxes.

in California's Central Valley that involved an exchange of water rights. Depending on the nature and complexity of the issues involved, staff time (including lawyers) needed to conduct negotiations and complete transactions regarding access issues may be considerable.

Physical Access

Addressing impediments to physical access can have a significant effect on costs (see Shaw, Coffin, Jani, Weaver/Hagans, Bair, Bell, Neal, Rectenwald, Bonsignore/Liske, Obradovich, Steere). For instance, roads that are abandoned, overgrown or washed out are harder to access than open roads. Wetland sites that are waterlogged or covered with weeds are harder to survey and work than dry open sites. Costs of getting equipment, materials (e.g., rocks, logs, soil, plants, culverts) and work crews to and from the restoration site vary widely, depending on the nature of what is being transported, distances traveled, difficulties associated with the transportation mode or route, and access conditions at the site itself. For instance, the cost and inconvenience of transporting woody debris may be minimal if such material is available near the restoration site, but increases significantly if a helicopter is needed to transport the material to a remote site.[6] Costs increase if construction, improvement or clearing of roads is required to gain access to a site, particularly if those roads then have to be decommissioned once the restoration is done. Costs associated with wetland restoration can be significantly higher if materials must be transported by barge instead of by land. In many cases, materials (e.g., excavated dirt, old culverts) must also be transported from the restoration site to a disposal site. Disposal costs can be particularly high if the materials removed are contaminated and must be treated or taken to specialized disposal sites.[7]

Other Site Characteristics

In addition to access, a variety of other site-specific factors also affect restoration strategies and costs. The following are examples of some of the more common factors cited by workshop participants. Many of these examples also serve to illustrate the contrasting strategies used in different landscapes and the role of professional judgment in dealing with local requirements and work conditions.

Road restoration — Landscape features can have a significant effect on road restoration costs (see Coffin, Dupont, Jani, Weaver/Hagans). For instance, road surface characteristics, stream crossing frequency, slope stability and number/size/depth of culverts are important cost factors. Work on public roads is generally subject to more stringent engineering and safety requirements than work on private roads. Restoration strategies vary, depending on the larger context in which they occur. For instance, culverts are commonly used at stream crossings in Idaho. However, flashing streams and heavy sedimentation in the northern California coastal mountains result in a high rate of culvert failure and therefore greater reliance on options such as rock armor crossings and railroad flatcar bridges.

Instream restoration — Instream treatment costs (see Shaw, Cocke, Bell, Lacy, Neal) depend on factors such as channel characteristics (e.g, depth, velocity, substrate, gradient), specialized

6- In some cases, helicopter use may also involve dealing with restrictions on flyovers around houses and power transmission lines.

7- Rectenwald provides a particularly compelling example of disposal of mercury-contaminated sediments at a dam removal site, which was conducted in accordance with Clean Water Act permit requirements. The work included core sampling of the reservoir, dewatering the sediments to prevent the release of contaminated water, and disposal of sediments and dewatering effluent. The contractor hired to carry out the work was required to be licensed to handle hazardous wastes. One of the legal agreements made between the agencies and the dam owner to implement terms of the restoration included a requirement for environmental insurance for mercury contamination.

equipment and material requirements, and whether the stream must be temporarily diverted around the work area. One treatment strategy is to introduce unanchored trees and boulders into the stream and allow nature to take its course. Another more engineered approach utilizes artificially anchored woody material and boulders. The latter approach involves more intensive use of hand crews and higher maintenance but is more commonly used, particularly in areas such as urban streams.

Revegetation — Revegetation costs can be significantly affected by irrigation and other requirements (see Shaw, Bair, Cocke, Neal, Steere). Irrigation costs depend on the availability of a nearby water source and the size of the irrigation system, as well as the period of time over which irrigation is needed. Costs are also affected by the extent to which plantings require protection from predators (e.g., cattle, deer) and the extent of ongoing maintenance needed to control nuisance vegetation (e.g., reed canary grass). Use of mechanized labor for planting is usually more costly than hand labor, but the success rate tends to be higher as well.

Wetland restoration — Wetland restoration strategy (see Bonsignore/Liske, Obradovich, Steere) depends on the type of wetland being created or restored.[8] Adjacent land uses are a significant cost consideration. An assessment (including consideration of soils, topography and hydrology) must be made to determine the suitability of the site for restoration. Availability of water is an important cost consideration; for instance, use of an existing water source and a gravity flow system is much less costly than pumping water to the site. For some projects, it may be necessary to demolish existing structures and/or relocate utility lines from the prospective wetland area. Costs also depend on the scope of the work (e.g., building levees, excavating ponds) and the extent to which maintenance of wetland structures (e.g., weirs, levees, pumps) and ongoing control of invasive plants and/or mosquitoes is needed once the initial work is completed. Costs associated with disposal of excavated soils vary widely, depending on whether the soils can be reused onsite or must be transported elsewhere and whether the soils are contaminated.

Fish screens — Fish screen requirements and costs (see Hayes, Hudson, Kepshire) are affected by issues related to flow rate, debris and sedimentation. Relevant cost factors include screen and screen structure requirements, extent of site preparation, and features such as the power source, cleaning system and backup system. Prefabricated screens that minimize the need for detailed engineering and rely on non-electric power sources (e.g., paddle wheels) are cost-effective options for some small diversions in places like Oregon. Such standardization is less suited to large complex diversions such as those found in California's Central Valley. Routine inspections and reporting requirements are important for identifying problems with screen functionality. Screens that can be retrieved from the water during the non-irrigation season are initially more costly but also have a longer life expectancy and are easier to inspect and maintain. Ease of maintenance affects not only cost but also the incentive to perform maintenance. Fish bypasses should also be monitored to ensure that year-to-year changes in the stream have not rendered them ineffective; bypasses

8- Steere, for instance, categorizes wetlands in San Francisco Bay to include bay habitats (tidal marshes, mudflats, lagoons, beaches, salt ponds), seasonal wetlands (diked wetlands, grasslands and associated wetlands) and creeks and lakes.

are also a useful tool for monitoring the effectiveness of the screen in protecting fish.

Coordination Requirements

Depending on the nature of the project, staff time devoted to planning and design may be significant and costly (see Wellman, Cocke, Neal, Obradovich, Steere). Project planning may require considerable consultation among engineers, geologists, hydrologists, biologists and other experts who can provide an understanding of the local landscape, determine the source of the problem and develop solutions. Wellman, for one, points out that sound planning goes a long way toward preventing cost overruns and delays in completing the construction phase of a project. Coordination may be desirable beyond the needs of a single project. For instance, Hayes cites the benefits of coordination among fish screening programs in California's Central Valley.

Coordination can be particularly time-consuming and costly for projects that are large and complex, require extensive interagency consultation or involve a large number or diversity of interest groups (see Neal, Hudson, Rectenwald, Obradovich, Steere). Interagency coordination may be challenging, as different agencies operate under different mandates and funding constraints, and may have different perceptions regarding what constitutes adequate restoration. While coordination may be costly, it is important to note that some restoration may not be feasible without the support of multiple partners who bring funding, technical expertise or other resources to the project. Coordination provides an opportunity to pool assets and better anticipate and resolve problems that can impede success of the project.

The feasibility and cost of conducting restoration on private lands depend critically on landowner cooperation (see Shaw, Cocke, Neal, Bonsignore/Liske, Obradovich, Steere). Landowners vary widely in the extent of their willingness to participate in restoration activities; cooperation becomes even more uncertain if multiple landowners are involved. A significant amount of staff time may be spent negotiating with landowners and (particularly in urban areas) holding public meetings with homeowner associations and other groups. A restoration project may have unintended effects on adjacent properties, in which case it may be necessary to negotiate with neighboring landowners regarding mitigation of such effects.[9]

Environmental Review, Permitting and Public Input Requirements

Depending on the nature and scope of the restoration, a project may be subject to environmental review and permitting requirements (see Coffin, Bair, Cocke, Neal, Hayes, Rectenwald, Bonsignore/Liske, Obradovich, Steere). For instance, Federal projects are subject to the documentation and public comment requirements of the National Environmental Policy Act (NEPA). States also have statutory requirements for environmental review — e.g., the California Environmental Quality Act (see Cocke), Washington's State Environmental Policy Act (see Neal). In cases where a project may result in "take" of a species listed under the Federal Endangered Species Act (ESA), applicable requirements (e.g., consultation, incidental take permit, habitat conservation plan) must be met. In addition, the Army Corps of Engineers, State resource agencies and some county agencies have permitting requirements for activities that fall within their jurisdiction. One reason for the differences in restoration costs among Federal, State and private lands pertains to differences in review and permitting requirements. The issue becomes further complicated if the restoration occurs on land in mixed ownership, i.e., with different

9- Bonsignore/Liske provide a mitigation example involving construction of levies around a restored wetland area to prevent water from seeping onto neighboring properties. Steere cites the need to accommodate adjacent or co-existing human uses as a major cost consideration in urban wetland restoration projects.

parcels subject to different permitting requirements.

Project review, permitting and consultation activities are important for anticipating and addressing environmental concerns and ensuring adequate opportunity for public input. These requirements may also add significantly to the cost and time required to complete a project, particularly in cases where the project is large in scale, controversial or affects a large number or variety of stakeholders (see Rectenwald). Controversy can arise from any number of sources. For instance, road decommissioning may raise concerns among hikers or other user groups regarding loss of access to a recreational area. Adding woody debris to streams may raise concerns by kayakers. Projects that have the potential to affect a multiplicity of interest groups (e.g., dam removal, urban restoration) may be particularly demanding in terms of environmental documentation and public input. However, while satisfying such requirements may be costly (sometimes even costlier than the restoration itself), inadequate attention to these requirements may increase the likelihood of public opposition or litigation once the project is underway, which is also costly.[10]

Scheduling Issues

Restoration costs are affected by the need to accommodate activities that are going on simultaneously with the restoration (see Wellman, Weaver/Hagans, Bell, Neal, Hayes, Hudson, Obradovich). For instance, construction may be limited to certain hours of the day to alleviate noise concerns. Fish screening projects may be timed to minimize interference with migrating salmon or the irrigation season. Extraordinary weather events may occur that delay completion of the work. Restoration on private land may be interrupted if the landowner decides to temporarily divert equipment to other, higher priority uses. Significant delays between project planning and mobilization may require that the original plans (including environmental documentation) be revisited and perhaps modified before proceeding with implementation. Construction delays associated with delays in obtaining funding, permits or easements may result in scheduling conflicts with other projects and perhaps (in a worst case scenario) postponement of the project until the following season. Regardless of the reason for delays, the resulting downtime can add to the cost of the project. Conversely, scheduling may also be advantageous to a project. For instance, cost savings may occur if restoration can be scheduled to take advantage of heavy equipment that may already be at a site for another purpose, or if restoration at multiple nearby sites can be simultaneously scheduled to ensure efficient use of equipment that will need to be mobilized to do the work.

Contract Versus In-House

An important consideration in restoration planning is whether to conduct the work in-house or under contract (see Hudson, Kepshire). Agency practices in this regard vary widely. For instance, some agencies design their own fish screens and contract out the construction. Others have an in-house "shop" that constructs screens (sometimes according to standardized design criteria), with installation handled either by agency crews or contractors. Screen shops tend to be cost-effective in situations where standardized screen designs have wide applicability.

The choice between conducting restoration in-house or under contract involves consideration of factors such as project cost, project control, project liability and the extent of in-house expertise and resources (see Bair, Cocke, Neal). When construction is contracted out, the project sponsor may incur significant planning and administrative costs associated with project design, review of proposals and contract monitoring. In such cases, the

10- For Federal projects subject to NEPA requirements, one potentially cost-effective strategy is to cover multiple projects in a single NEPA document. Potentially controversial projects, however, should not be bundled in this manner, as controversy regarding any single project can hold up implementation of all the projects covered by the NEPA analysis (see Bair, Cocke).

contractor assumes most of the liability associated with completion of the project.[11] Liability concerns tend to bid the contract price up. When construction is done in-house, plans must be sufficiently detailed to satisfy up-front permitting requirements, but the need for detailed specifications may be somewhat mitigated by the availability of in-house engineering and biological expertise to assist with the project as it progresses. In such cases, the project sponsor assumes the liability associated with project problems and delays. "Intermediate" arrangements are also common, whereby agency staff directs the work of operators and equipment hired on hourly contracts. Hourly contractors are likely to rent equipment on an as-needed basis rather than incur the overhead cost associated with purchase and maintenance of equipment.

FEASIBILITY OF EXTRAPOLATING COSTS FROM INDIVIDUAL PROJECTS TO LARGER GEOGRAPHIC AREA

In order to estimate habitat restoration costs to recover ESA-listed salmonids, it is first necessary to comprehensively evaluate restoration needs (see Huppert, Dupont, Weaver/Hagans, Bair, Cocke). Concerted efforts are being made by government, private sector and local watershed groups to conduct on-the-ground assessments that focus on limiting factors and ways to reduce their influence. These assessments are typically done at the watershed level, as restoration problems are best understood in the context of the watershed in which they occur. However, detailed watershed assessments are being conducted on only a portion of salmon/steelhead habitat. Resources to perform such assessments are limited, and ability to perform such assessments on private lands is often contingent on landowner cooperation. For areas where on-the-ground assessments are not available, it may be necessary to resort to more approximate assessments of restoration needs based on less detailed sources of information. For instance, topographic maps are useful for identifying relevant landscape features, such as the distribution of existing roads and their intersection with stream crossings. It is also important to consider the limitations of topographic maps and other data sources.[12] Developing a comprehensive picture of aggregate salmon/steelhead habitat restoration needs thus requires critical evaluation and synthesis of information of varying quality gathered from many different sources.

Estimating costs associated with addressing aggregate restoration needs is also problematic. Workshop participants (see Coffin, Weaver/Hagans, Bair, Bonsignore/Liske, Steere) emphasize the importance of on-site surveys to ensure that project cost estimates accurately reflect site-specific requirements. However, recovery plans for ESA-listed salmonids will require estimation of aggregate restoration costs associated with multiple projects over an extended geographic area. The infeasibility of developing detailed on-site cost estimates for every such project makes it necessary to consider the possibility of extrapolating the costs of individual restoration projects to a larger geographic scale.

Most of the workshop participants who discussed the feasibility of extrapolation were willing to consider it, though under limited circumstances and with the understanding that such cost estimates would have a large margin of error.[13] Given the

11- For Federally funded projects, an additional cost consideration is the Davis-Bacon Act, which requires construction contractors to pay hired laborers the local prevailing wage rate for work of similar type. Other funding entities may also have similar prevailing wage requirements of their own.

12- For instance, Coffin and Weaver/Hagans note that on-the-ground road surveys frequently reveal the presence of roads that do not appear on existing maps. Hudson and Kepshire note that existing inventories of water diversions may provide good coverage of larger unscreened diversions, but a significant number of smaller diversions are likely to be missing from such inventories; determining ownership and legal status of diversions is also a challenge.

13- Several workshop participants, however, were hesitant to consider extrapolation under any circumstances. With regard to streambank restoration, Bair states, "It is possible, however, that standardized costs estimated for larger areas (watersheds and greater) may never be appropriate, and that working from the individual conditions at each restoration site may be the only way to develop reasonable estimates of project costs" (p. 112). Obradovich notes that "Expanding [wetland] cost estimates to watershed, ESU or state level seems to be an iffy proposition at best" (p. 223). Steere similarly points out that "While estimates [of urban wetland restoration costs] can be made, they have great variability, and some practitioners believe that attempting to make them on the basis of 'per acre restored' or 'per cubic yard of earth moved' are at best inadequate and at worst misleading ..." (p. 225).

sensitivity of restoration costs to site-specific characteristics, they generally recommended that data on project costs be extrapolated only to other projects involving similar work done in the same watershed to address similar problems (see Coffin, Dupont, Weaver/Hagans, Cocke, Hampton, Hudson). Two specific approaches to cost extrapolation consistent with this advice were suggested at the workshop.

Method A: Base cost estimates for a given type of project on recent historical costs for the same type of project in the same watershed.

Method B: Base cost estimates on predictions derived from models that explicitly relate costs to characteristics of the project and the landscape in which it occurs. Two models were presented at the workshop that illustrate this approach:

> Using data on 37 instream restoration projects in north coastal California, Hampton estimates a multiple regression model relating cost per stream mile to stream gradient, number of structures per stream mile and stream length. The overall fit of the model was $r^2=0.46$, with the coefficient on one of the explanatory variables (structures per stream mile) being statistically significant at the 95% level. Hampton cautions that the data used in his analysis did not include complete costs for planning, permitting, monitoring and maintenance.
>
> Hudson uses a sample of fish screen projects in the State of Washington to estimate a model relating project cost to design flow. Three versions of the model were estimated using data on screens designed for flows of 1–15 CFS, 1–58 CFS and 1–210 CFS. Goodness-of-fit was high for all three versions ($r^2 = 0.803$, 0.865 and 0.891 respectively) and was even higher ($r^2 = 0.942$) for a fourth version that was based on proposed rather than actual costs. Hudson also provides interval estimates (±25% of the costs indicated on the cost curves) to reflect uncertainties regarding the comparability of costs across projects.

Specific suggestions made by workshop participants regarding methods A and B — as well as their more general observations regarding the availability and quality of restoration project data and the factors that drive restoration costs — would appear to suggest the following:

> Both methods A and B require cost and location data on individual restoration projects. Available data are not likely to include full life cycle cost information at the individual project level. Thus efforts will need to be made to ensure that the data include at least comparable cost elements across projects, with the expectation that subsequent adjustments to these cost estimates may be required to account for whatever cost elements are missing from the analysis.
>
> Method A involves estimation of watershed-specific statistics such as mean cost per project, and therefore requires that a sufficiently large and representative sample of projects be available for each type of restoration activity in each watershed.[14] In applying method A, it will be desirable to limit the

14- The U.S. Geological Survey (USGS) developed a system of eight-digit hydrologic unit codes (HUCs) to categorize major watersheds in the U.S. according to four classification levels. The first two digits of a HUC classify the U.S. into 21 regions, the second two digits define 222 subregions within the regions, the third two digits define 352 accounting units that nest within or are equivalent to the subregions, and the fourth two digits define 2,149 cataloguing units within the accounting units. Regions, subregions, accounting units and cataloguing units are referred to respectively as 1st, 2nd, 3rd and 4th field HUCs. California is divided into 153 4th field HUCs, Oregon into 92, Washington into 73 and Idaho into 92. There are 368 4th field HUCs in the four states combined (less than the sum of the number in each state, as some HUCs overlap state boundaries), and 294 of these 368 HUCs overlap with one or more salmon/steelhead ESUs.

The Natural Resources Conservation Service (NRCS), in coordination with the USGS, is updating national watershed maps to the 5th and 6th field levels. State-level mapping efforts have been ongoing as well. For instance, California's Interagency Watershed Mapping Committee (IWMC) coordinates changes and enhancements to California's official watershed map (known as Calwater), which delineates the landscape to a sub-watershed level of detail (3,000–10,000 acre areas). The IWMC, which includes State and Federal agencies, is working to ensure that Calwater meets State and Federal mapping standards (see data to recently completed projects to better ensure that the data reflect current design standards and the current state of restoration technology. Depending on data availability, attempts should also be made to further stratify watershed-specific cost estimates on the basis of other relevant cost factors.[15]

Method B involves estimating the relationship of project costs to project and landscape characteristics that are hypothesized to affect costs. Method B thus requires detailed information on the characteristics of restoration projects and the landscape in which they occur. To the extent that available project data include information on project design standards, the model should be specified to capture the effect of changing design standards on costs. However, to the extent that design standard data are not available, it will probably be advisable to include only recently completed projects in the model (as in method A).

In order to link model predictions from method B to specific watersheds, descriptive landscape information will be needed for each watershed corresponding to the types of landscape variables included in the model. Method B is more data intensive but also potentially more informative than Method A, as it quantifies the relationship of project costs to project and landscape characteristics. The success of method B will be contingent not only on data availability but also the performance of the statistical model.

As indicated by workshop participants, extrapolation methods are likely to produce restoration cost estimates with a high margin of error. The particularly strong reservations expressed by two of the wetland experts regarding the feasibility of extrapolation would seem to suggest that wetland restoration requirements are particularly individualistic. Ongoing consultation with restoration practitioners will be advisable in the course of developing aggregate restoration cost estimates for salmon/steelhead recovery plans.

With regard to data requirements, many of the types of project-level data needed to apply methods A and B to restoration activities are being collected in the California Habitat Restoration Project Database (CHRPD) (see Carlson/Allen). The CHRPD is a work in progress and concerted efforts are being made to augment the database with projects originating from a variety of funding sources. Experience to date with the CHRPD suggests a number of ways in which databases maintained by project sponsors can be made more useful for cost analysis. For instance, while information on project location is essential for linking individual projects to their associated landscape characteristics, location information contained in project descriptions are often imprecise. While cost analysis is best done on the basis of actual rather than proposed costs, records of actual costs are not always maintained or reported in a sufficiently detailed manner by project sponsors to be useful for cost analysis. Some standardization of reporting requirements among project sponsors would facilitate cost analysis. Workshop participants developed a list of data elements that address this particular need (Table 1). Some project sponsors already have reporting requirements that closely resemble Table 1; it is important that such requirements be enforced (see Carlson/Allen).

http://www.ca.nrcs.usda.gov/wps/calwater/).

In terms of estimating habitat restoration costs at a watershed level, it should be noted that definition of the term "watershed" is somewhat ambiguous and subject to change over time. For instance, 4th field HUCs are sometimes referred to in common usage as "watersheds", although in areas where 5th field subwatershed mapping has been done (e.g., by the Forest Service in some of the national forests), the 5th field designation is likely to be referred to as a "watershed". In an upcoming update to Federal mapping guidelines, 3rd and 4th field HUCs (currently referred to as accounting and cataloguing units) will be renamed basins and subbasins, and newly delineated 5th and 6th HUCs will be named watersheds and subwatersheds.

15- Dupont, for instance, suggests that project costs be stratified by land ownership as well as watershed.

OTHER ISSUES AND RECOMMENDATIONS

While the focus of the workshop was on habitat restoration cost estimation, participants also suggested ways to enhance the effectiveness of restoration both at the individual project level and at the large scale planning level. Their recommendations are as follows.

Obtaining Comprehensive Picture of Restoration Activity

Restoration funding originates from many sources and is distributed through many channels, making it difficult to comprehend the full extent of restoration in terms of projects or expenditures. In order to understand the "big picture", it is important that this picture include information on projects sponsored by the various funding sources. It is also important that monies not be double counted, as monies may be transferred through one or more channels before being allocated to specific projects. Even determining which projects to classify as salmon habitat restoration may be problematic, as some projects are intended to specifically benefit salmon, while others are motivated by a broader environmental interest (e.g., clean water, general wildlife benefits) that may include but not be specifically focused on salmon.

While ambiguities exist regarding exactly which monies and projects to attribute to salmon restoration, it is nevertheless clear that some accounting of this type must be made. Significant sums of money have been allocated to restoration and it is important to determine what has been accomplished as well as what remains to be done. Databases such as the CHRPD (see Carlson/Allen) are important for documenting the scope and distribution of restoration activities across the landscape. The CHRPD will be a useful tool for recovery planning for ESA-listed salmon and steelhead in California.

Ensuring Maximum Benefits from Restoration Funds

It is important that restoration monies be allocated among projects in a way that yields maximal benefits to salmonids. However, as noted by Huppert, "A problem in applying these [cost-effectiveness analysis, benefit-cost analysis] to salmon habitat restoration is the difficulty of linking the costs of specific restoration activities to the broad objectives of salmon restoration, which typically include increased numbers and genetic diversity of naturally spawning fish" (pp. 24–25). Given this difficulty, benefits to fish are often measured in terms of how well the restoration activity addresses limiting factors (e.g., sedimentation, water temperature) that impede salmon recovery. Measures of restoration effectiveness (whether expressed in terms of fish population parameters or limiting factors) are essential for providing the feedback necessary to evaluate and improve restoration techniques and for prioritizing projects for funding. Isolating the benefits of any single restoration project relative to the totality of restoration activities within a watershed is often problematic. Even determining the effects of entire watershed restoration programs can be difficult, as the effect of such programs on fish populations takes time to become apparent and must be distinguished from the effects of other confounding human and environmental factors.

Several workshop participants discuss ways to relate funding decisions to restoration benefits:

> Tomberlin provides an optimization model for allocating restoration funds both temporally and across space (e.g., among projects, rivers, watersheds). He identifies a number of factors that should be explicitly considered in funding allocation decisions — namely, the objective that allocation is intended

to achieve, the size of the available budget, the nature of the relationship between restoration effort and benefits, the degree of uncertainty in the effort-benefit relationship, and the decision maker's attitude toward risk. Tomberlin also provides stylized examples that demonstrate some of the insights that can be gained from his model. For instance, he shows that — when the objective is to maximize the sum of restoration benefits across two rivers, both rivers share an identical sigmoidal effort-benefit relationship that is known with certainty, and the restoration budget is too small to be of much benefit to either river if divided between rivers — funding should be concentrated in one of the rivers. However, if the effort-benefit relationship is uncertain, funding should be distributed between the two rivers to reduce the chance of getting no benefits at all. More complicated variations of these scenarios can also be developed (e.g., allowing each river to exhibit a different effort-benefit relationship).

Weaver/Hagans focus on a particular type of restoration activity (road repair) as it relates to a particular restoration benefit (preventing sediment delivery into streams). They emphasize the importance of predictive (i.e., "forward looking") sediment source inventories and describe how to develop such inventories at screening, reconnaissance and full assessment levels. They also describe a systematic process for determining whether to upgrade, maintain or decommission a road based on five steps: problem identification, problem quantification, prescription development, cost-effectiveness evaluation and prioritization, and implementation. Specific outputs of their process include a risk reduction plan, a budget, a cost-effectiveness analysis and prioritization of sites to be treated.

Recognizing and Addressing Life Cycle Requirements of Restoration Projects

Restoration sponsors are often encouraged to use funding in ways that are visible and engender public support. This translates into an inordinate attention to the more visible aspects of restoration, namely construction. In some cases, this emphasis on "moving dirt" is further reinforced by legal, policy or contractual constraints that effectively limit the amount of money spent on planning, maintenance and monitoring — less visible aspects of restoration that are nevertheless critical to project success. Inadequate attention to planning can lead to delays, cost overruns and poor execution of project requirements in the construction phase. Given the importance of maintenance to the success of a project, it is important to realistically appraise whether funding and other incentives are adequate to ensure that maintenance requirements will be met; projects should not proceed without a reasonable expectation of adequate maintenance. Monitoring is essential for evaluating the success of restoration projects in meeting their goals and objectives, and also provides the type of feedback needed to evaluate and improve restoration techniques.[16]

Restoration practitioners are well versed in the life cycle requirements and costs of restoration projects.[17] It is also important that policy makers and the public have a realistic appreciation of the need to address total project requirements, the inexact nature of restoration science and the length of time it takes to see results.[18] In order to encourage greater attention to maintenance and monitoring requirements, it is important to consider why these activities are not

16- While monitoring is typically viewed as a post-construction activity, Weaver/Hagans also use a form of monitoring in the construction phase of their projects by requiring their operators to record the time and effort spent on various tasks. This information is used to refine cost estimation procedures and improve project efficiency.

17- Dupont, for instance, provides excellent examples of life cycle costs for stream crossings in Idaho.

adequately addressed in the first place. For instance, monitoring can add significantly to the cost of a project,[19] and landowners may be particularly reluctant to pay for research-related monitoring. In such instances, collaborative or cost-sharing arrangements with research-oriented entities may be desirable.[20]

Streamlining the Regulatory Process

Regulatory and permitting requirements serve a valuable function by providing protection for vulnerable species and ensuring adherence to clean water and other environmental standards. However, the permitting process often requires clearances from multiple agencies and can be lengthy, costly and uncertain in terms of timing and outcome. Some progress on streamlining has been accomplished, particularly for smaller restoration projects.[21] Continuing efforts are needed to ensure that permitting requirements are clearly and explicitly defined and that the permitting process moves forward in a timely manner with minimal "red tape" (see Bell, Hayes).

Enhancing Public Participation

A variety of restoration and monitoring programs exist that encourage and facilitate public involvement in habitat restoration. Public participation is valuable for fostering an attitude of stewardship toward habitat and for augmenting restoration efforts over and above what agencies can provide with their limited resources. It is important that public involvement be supported with adequate funding to organize, train and otherwise support volunteer participation in restoration efforts.[22]

A variety of programs exist that encourage the participation of private landowners in salmon habitat restoration projects by providing design and other technical assistance or facilitating permit acquisition and access to funding sources.[23] While many take advantage of these services, others are not interested or are concerned that such participation may draw attention to themselves in terms of agency oversight of their land use activities. Positive incentives and "win-win" situations, of course, work best for obtaining landowner cooperation.[24]

Managing Projects Effectively

Restoration is particularly challenging for large or complex projects that involve multiple agencies with overlapping jurisdictions and diverse stakeholders. Workshop participants emphasize the importance of managerial skills as well as technical expertise in ensuring the success of restoration projects. For example:

> Neal describes project management procedures in King County that may be useful in other populated urban settings. She points out the importance of restoration design teams that include a range of professional disciplines. The teams are organized by watershed, which allows

18- Cocke provides a particularly vivid description of the dynamic nature of stream systems and the long-term effects of human behavior and natural processes on the system. He emphasizes the need to incorporate adaptive management into the restoration planning process. He notes that restoration often involves laying the groundwork for continuing as well as current beneficial effects (e.g., trees planted to stabilize stream banks also serves as a future source of large woody debris) and makes the point that "...the most important aspect of restoration work is time" (p. 119).

19- Hayes cites a case in which slots were built (at considerable expense) into a Central Valley pumping facility to facilitate monitoring.

20- According to Neal, King County maintains separate budgets for restoration projects and research-oriented assessments, with research sometimes undertaken collaboratively with the University of Washington. Hayes notes that the CalFED Bay Delta Program sometimes engages in cost-sharing arrangements with irrigation districts for research-related monitoring at fish screen facilities.

21- Hayes cites as an example the Anadromous Fish Screen Program — established under the Central Valley Project Improvement Act — which has streamlined its permitting process by ensuring that a single staff person works with an applicant on all permitting requirements.

22- Neal describes King County's sponsorship of volunteer planting events, including provision of parking/shuttle buses, team leaders, refreshments, tools and planting instructions. Rectenwald notes the importance role played by watershed groups in community-based restoration planning and the significant amount of effort and citizen involvement (as well as monetary grants) needed to make such groups successful.

23- Hayes cites the work of the Family Water Alliance, a program sponsored by the Natural Resources Conservation Service that works with farmers on small screen projects. Hayes also points out that the CVPIA Anadromous Fish Screen Program streamlines its funding process by providing irrigators with access to multiple fish screen funding sources via a single application.

members to develop detailed knowledge of that watershed and long-term relationships with relevant stakeholders and the staff at regulatory agencies who have jurisdiction in the watershed. Regulatory agencies are consulted early on to ensure that environmental requirements are reflected in the early stages of project design. Collaborative and pro-active arrangements such as this help build long-term relationships with regulatory agencies and the public that are based on trust and ensure successful restoration.

In his discussion of a dam removal project in California's Central Valley, Rectenwald provides many specific suggestions for dealing with the complex coordination requirements of the project. For instance, he points out the importance of understanding the mandates and policies of different agencies and dealing with agency aversion to setting a precedent by changing standard ways of conducting business. He emphasizes the need to appreciate the motivations and concerns of the dam and water rights owner. He encourages the use of community knowledge to augment agency knowledge regarding the history of salmon runs in the watershed. He notes the contribution that local watershed groups make to community-based planning. To enhance public participation, he suggests scheduling meetings at times and places convenient to the public and ensuring that the same person is consistently available to represent the project in interactions with the public. Rectenwald advises full and early disclosure of information relevant to the project (including any potential adverse effects on stakeholders), outreach activities that allow stakeholders to participate in the development of options that mitigate adverse effects, and environmental documentation that includes the specific mitigation measures developed in the course of negotiations. His case study vividly illustrates the importance of skillful management and collaboration in ensuring the success of protracted, complex and controversial restoration projects.

FINALLY...

Restoration involves the application of technology to complex natural systems within an often complicated legal, institutional and social context. Restoration is ultimately a human activity — conducted by people who respond to restoration opportunities, constraints and incentives in adaptable and ingenious ways. Workshop presenters provided insights into all these dimensions of restoration. We thank them for sharing their knowledge and expertise with us.

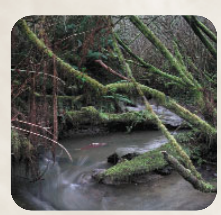
Table 1. Restoration project data requirements for cost analysis, as suggested by workshop participants

Goals and measurable objectives
Project description
Project location[1]
Project manager (contact person)
Funding source(s)
Project costs[2]
Planning
Design
Permitting/environmental review
Construction[3]
Monitoring
Maintenance
Overhead

1- Location should be identified in as specific a manner as possible. Some standardization of location descriptors would be helpful.

2- Both proposed and actual costs should be provided for each cost category. Cost estimates should be complete, including matching funds.

3- Construction costs should be broken down by labor, materials and equipment. Labor expended in each cost category should be reported in person hours and dollars.



24- Hudson cites an instance where, in lieu of screening an existing water diversion, the Bureau of Reclamation assisted the landowners in obtaining funding to excavate wells and install a sprinkler system, thereby allowing elimination of the diversion and benefitting both the landowners and the fish. Rectenwald notes that wildfire prevention can serve dual purposes in terms of reducing sedimentation in a creek and protecting property in the community. Kepshire notes that pump screens, which keep snails as well as fish out of irrigation ditches, are popular among Oregon farmers.